AD-A272 963

Technical Report A-93-5
October 1993

US Army Corps
of Engineers
Waterways Experiment
Station

Aquatic Plant Control Research Program

Effects of Benthic Barriers on Macroinvertebrate Communities

by *Barry S. Payne, Andrew C. Miller*
Environmental Laboratory

Thomas Ussery
University of Texas at Arlington

Approved For Public Release; Distribution Is Unlimited

Prepared for Headquarters, U.S. Army Corps of Engineers

Aquatic Plant Control
Research Program

Technical Report A-93-5
October 1993

Effects of Benthic Barriers on Macroinvertebrate Communities

by Barry S. Payne, Andrew C. Miller
Environmental Laboratory

U.S. Army Corps of Engineers
Waterways Experiment Station
3909 Halls Ferry Road
Vicksburg, MS 39180-6199

Thomas Ussery

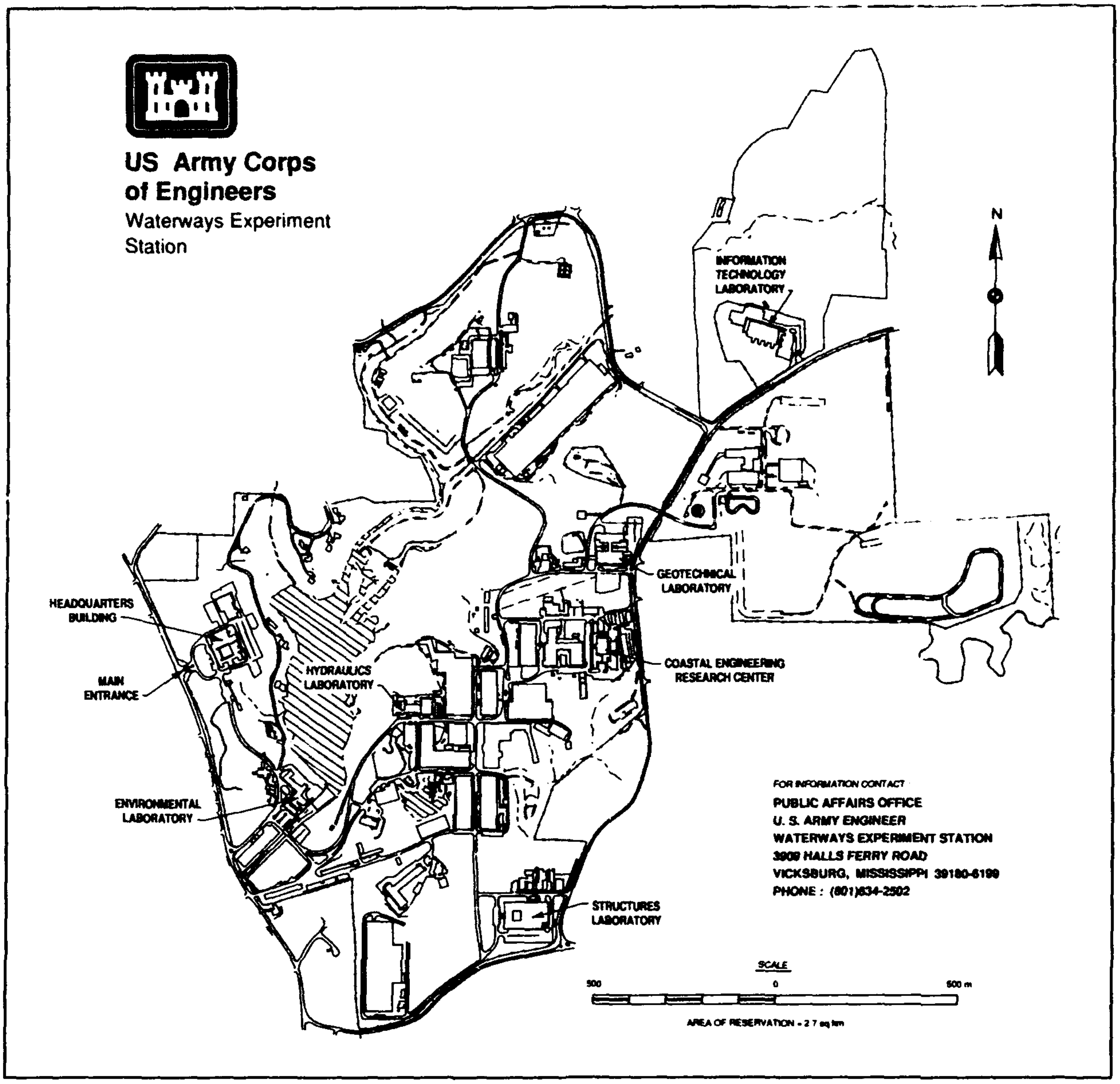
Department of Biology
University of Texas at Arlington
Arlington, TX 76019

Final report

Approved for public release; distribution is unlimited

Prepared for U.S. Army Corps of Engineers
Washington, DC 20314-1000

Under APCRP Work Unit 32579



Waterways Experiment Station Cataloging-in-Publication Data

Payne, Barry S.
Effects of benthic barriers on macroinvertebrate communities / by Barry S. Payne, Andrew C. Miller, [and] Thomas Ussery ; prepared for U.S. Army Corps of Engineers.
27 p. : ill. ; 28 cm. — (Technical report ; A-93-5)
Includes bibliographical references.
1. Aquatic plants — Control — Environmental aspects. 2. Aquatic invertebrates. 3. Aquatic ecology. I. Miller, Andrew C. II. Ussery, Thomas A. III. United States. Army. Corps of Engineers. IV. U.S. Army Engineer Waterways Experiment Station. V. Aquatic Plant Control Research Program (U.S. Army Engineer Waterways Experiment Station) VI. Title. VII. Series: Technical report (U.S. Army Engineer Waterways Experiment Station) ; A-93-5.
TA7 W34 no.A-93-5

Contents

Preface

The work reported herein was conducted as part of the Aquatic Plant Control Research Program (APCRP), Work Unit 32579. The APCRP is sponsored by the Headquarters, U.S. Army Corps of Engineers (HQUSACE), and is assigned to the U.S. Army Engineer Waterways Experiment Station (WES) under the purview of the Environmental Laboratory (EL). Funding was provided under Department of the Army Appropriation No. 96X3122, Construction General. The APCRP is managed under the Environmental Resources Research and Assistance Programs (ERRAP), Mr. J. L. Decell, Manager. Mr. Robert C. Gunkel was Assistant Manager, ERRAP, for the APCRP. Technical Monitor during this study was Ms. Denise White, HQUSACE.

From 1988 through 1992, personnel of the EL conducted field studies of the environmental effects of synthetic fabric barriers used for aquatic plant control. Biological effects studies were conducted by Drs. Barry S. Payne and Andrew C. Miller of the Environmental Resources Division (ERD) of the EL and Mr. Thomas Ussery of the University of Texas at Arlington (UTA) in parallel with physical and chemical effects studies led by Mr. Harry Eakin and Dr. John Barko of the Environmental Research and Simulation Division (ERSD) of the EL. This report presents and discusses the results of the biological effects studies.

Logistical and sampling assistance at Lake Guntersville were provided by Messrs. D. Murphy, D. Brewster, and L. Mangum of the Tennessee Valley Authority and by Mr. K. Piggott, WES. At the Lewisville Aquatic Ecosystem Research Facility, Mr. Michael Smart, WES, provided logistical and sampling assistance, and at Eau Galle Reservoir, these services were provided by Messrs. William James, D. Dressel, and E. Zimmer of the Eau Galle Limnological Laboratory. Mses. Sarah Wilkerson and Erica Hubertz of WES assisted in the preparation of figures, sample processing, and data entry. This report was prepared by Drs. Payne and Miller (WES) and Mr. Ussery (UTA).

During the conduct of this study, Dr. John Harrison was Director, EL, Dr. C. J. Kirby was Chief, ERD, and Dr. E. Theriot was Chief of the Environmental Resources Branch, EL. At the time of publication of this report, Director of WES was Dr. Robert W. Whalin. Commander was COL Bruce K. Howard, EN.

This report should be cited as follows:

> Payne, B. S., Miller, A. C., and Ussery, T. (1993). "Effects of benthic barriers on macroinvertebrates," Technical Report A-93-5, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

1 Introduction

Background

Covering the bottom of aquatic habitats to prevent growth of nuisance macrophytes is a management option that has been employed since the late 1960's (Born et al. 1973; Nichols 1974). Techniques have included placement of sand and gravel as well as sheeting, the latter usually made of plastic or synthetic fabric. Artificial barriers are held in place by an array of pins driven through the barrier and into the underlying substrate. Barriers both block light and present an impenetrable barrier to upward growth of shoots. In most instances, barriers are used for localized control of plants in high use areas such as boat harbors, boating lanes, and swimming areas.

Positive and negative aspects of benthic barrier use are generally known from previous evaluations (Cooke 1986; Lewis, Wile, and Painter 1983; Mayer 1978; Cooke and Gorman 1980), but little quantitative research has been conducted that specifically deals with benthic macroinvertebrate response to barrier placement (Engel 1984). The U.S. Army Engineer Waterways Experiment Station has recently completed parallel investigations of physical and biological effects of synthetic barriers on benthic conditions. The present report presents the results of field evaluations of the effects of barriers on benthic macroinvertebrates in Eau Galle Reservoir in west central Wisconsin, Lake Guntersville in northeastern Alabama, and ponds of the Lewisville Aquatic Ecosystem Research Facility of the Corps of Engineers in north central Texas.

Purpose and Scope

The purpose of this report is to describe density and community composition changes in benthic macroinvertebrates under experimentally placed barriers and in adjacent reference sites. These data will be used by personnel of the Corps to assess the environmental effects of benthic barriers used in aquatic plant management programs.

2 Study Sites and Methods

Study Sites

Eau Galle Reservoir is a small (0.62-km^2) impoundment built by the Corps of Engineers on the Eau Galle River in west-central Wisconsin (Figure 1). A single 6.1-m by 12.2-m benthic barrier was deployed during late August 1988 in a plant bed dominated by *Ceratophyllum* but also containing *Potamogeton*.

Benthic barriers (each 6.1 m by 12.2 m) were placed at five locations in Lake Guntersville on May 22, 1990 (Figure 2). Lake Guntersville is a large Tennessee Valley Authority reservoir on the Tennessee River in northeastern Alabama. The barrier placed at site 1 was lost to vandalism soon after placement. Barriers were placed in the Town Creek embayment based on historical information on the distribution of *Hydrilla*. However, soon after barrier placement, a near total decline of submersed macrophytes occurred in the Town Creek embayment.

Four benthic barriers (each 6.1 m by 6.1 m) were placed in experimental ponds of the Lewisville Aquatic Ecosystem Research Facility of the U.S. Army Engineer Waterways Experiment Station on 11 June 1990. These ponds were approximately 0.75 acre (3,035 sq m) in surface area with an average depth of 2 m and were part of a complex located in an abandoned fish hatchery below the Lewisville Lake Dam (Figure 3). Two barriers were placed in each of two adjacent ponds. Dense *Nais* dominated the areas in which barriers were placed. Substantial macrophyte biomass was present at the time of barrier placement, but the dense plant bed had not yet established. A relatively detailed time series of core sediment samples with macroinvertebrates was collected, including samples on 11, 18, and 27 June, 20 July, and 13 September 1990. Barriers were removed on 16 November 1990, and samples were obtained the following summer on 2 July 1991.

Among all three study locations, the depth of barrier placement ranged from 1.5 m to 3.0 m and was shallowest at the Lewisville ponds. A special concern associated with the shallow barriers in north central Texas was that sunlight would heat the brown barrier material and raise water

temperatures below the barriers to levels not tolerated by aquatic life. However, water temperature below barriers was never higher than near-bottom temperatures of the water just above the barriers (Figure 4).

The barriers used at all locations were Bottom Line™ Benthic Barrier Fabric (Dow Corning Corp., Midland, MI).

Methods

Core samples of sediments including macroinvertebrates were obtained at sites of barrier placement and adjacent reference areas just outside of the influence of each barrier. Caution was taken not to include live plant shoots in these samples, because macroinvertebrates occurring on plant stems are often different than those occurring in sediments below plants. Five samples were obtained from beneath each barrier and each adjacent reference site on each date of sampling. Approximately 95 percent of sediment-associated macroinvertebrates in such samples are restricted to the upper 5 cm of sediment (Beckett, Aartila, and Miller 1992a). Thus, only the upper 5 cm of each core sample was analyzed.

At Eau Galle Reservoir, the barrier was laid down in late August. The reference and barrier site were subsequently sampled on 27 September 1988 and 28 July 1989. At Lake Guntersville, samples were collected at two barrier and two reference sites on 10 July, approximately 6 weeks after barrier placement. A relatively detailed series of samples was collected at the Lewisville ponds. Hours prior to barrier placement on 11 June 1990 samples were collected throughout the areas to be used as both reference and barrier sites. Subsequently, samples were collected from each barrier and reference site on 18 June, 27 June, 20 July, and 13 September 1990. The barriers were removed from both ponds on 16 November 1990, and the corners of each barrier site were marked. The following summer, on 2 July 1991, the ex-barrier sites and reference sites of one of the ponds were sampled to analyze recovery. The second pond was not sampled in 1991 because it had inadvertently been allowed to largely drain (due to a leaky clay liner and inadeqaute attention to water replenishment) during the winter of 1990-1991.

Sediment samples were fixed in the field in a 5-percent formalin solution containing Rose Bengal stain. Samples were returned to the laboratory and sieved through a 0.5-mm mesh screen. All macroinvertebrates were sorted from material retained on the sieve and enumerated by major taxa. The total number of individuals per square metre (density) was estimated from these counts per core sample.

At Lewisville, no significant differences in density were noted between barrier and adjacent reference sites prior to barrier placement. Furthermore, at both Lake Guntersville and the Lewisville ponds, where multiple barrier and reference sites were sampled, differences among barrier sites

or among reference sites were not significant and never substantial in comparison to post-treatment differences between all barrier versus all reference sites. Thus, to simplify presentation of results, data for multiple barrier and multiple reference sites at Lake Guntersville and the Lewisville ponds have been combined.

Barriers at both Eau Galle Reservoir and the Lewisville ponds were highly effective at preventing plant growth. Macrophyte growth did not occur in the areas that barriers were placed in Lake Guntersville. Gas buildup under the newly placed barriers, probably from plant decomposition (Gunnison and Barko 1992), was substantial enough at Lewisville that a large diameter polyvinylchloride pipe had to be rolled over the mat during the first 2 weeks to push gas out from under the barriers to prevent them from floating off the bottom. Subsequent buildup of gas was not a problem.

3 Results

Effects of Barrier Placement on Density

Barriers greatly reduced, but did not entirely eliminate. benthic macroinvertebrates at all locations soon after placement (Figure 5). After 1 month at Eau Galle Reservoir, densities below the barrier were 31 percent of those at adjacent open areas, although high variability in density beneath the barrier kept this initial difference from being significant at the 0.05 probability level ($t=1.31$; $d.f.=8$; $p>0.2$). After 6 weeks at Lake Guntersville and after 5 weeks at the Lewisville ponds, densities were significantly reduced below barriers to approximately 10 percent of densities at adjacent reference sites. At Guntersville, density equaled 1,184 individuals per square metre in reference sites and only 148 individuals per square metre under barriers ($t=2.41$; $d.f.=18$; $p<0.05$). At Lewisville, density equaled 1,628 individuals per square metre in reference sites and only 197 individuals per square metre beneath barriers ($t=2.15$; $d.f.=38$; $p<0.05$).

These initial reductions in density were maintained, as evident from longer term observations at both Eau Galle and Lewisville. The 69-percent reduction in density evident at Eau Galle 1 month after barrier placement increased to 86 percent the following summer (Figure 6). On 28 July 1989, density in reference site sediments equaled 5,710 individuals per square metre versus 791 individuals per square metre under the barrier ($t=2.50$; $d.f.=8$; $p<0.05$). A very rapid reduction in density at Lewisville on an order of magnitude within 1 week was maintained throughout the summer (Figure 7; Table 1).

Despite a steady decline of macroinvertebrates in natural sediments in the Lewisville ponds during the summer, density below barriers was always lower (Figure 7; Table 1). One week after barrier placement, average density at reference sites had declined by 31 percent to 5,723 individuals per square metre but averaged just 567 individuals per square metre beneath barriers. On 20 July, density at reference sites averaged only 1,628 individuals per square metre, but was still nearly an order of magnitude greater than the density measured under barriers (197 individuals per square metre). By 13 September, density at reference sites had declined to only 888 individuals per square metre, and a significant difference

could no longer be detected between this naturally low density and the still low density of macroinvertebrates under barriers (370 individuals per square metre). Also, regrowth of macrophytes through slits cut in the barriers for core sampling had become substantial enough by September that it was decided that no further barrier-to-reference comparisons would be useful. Barriers at Lewisville were removed at the end of the growing season on 16 November.

Recovery of Density After Barrier Removal

Density recovered once barriers were removed at Lewisville (Figure 7; Table 1). On 2 July 1991, macroinvertebrates were relatively dense at both reference sites and ex-barrier sites. Density at reference and ex-barrier sites equaled 4,495 individuals per square metre and 2,417 individuals per square metre, respectively. These early summer densities were similar to those observed during late June (3,183 individuals per square metre) and late July (1,628 individuals per square metre) at reference sites in the previous year. Densities were not significantly different at reference versus ex-barrier sites on 2 July 1991.

Barrier Effects on Community Composition

The natural benthic macroinvertebrate community at both Eau Galle Reservoir and Guntersville Lake was somewhat more diverse than at the Lewisville ponds, with the dominance of oligochaetes comprising a principal difference among locations (Table 2). At all locations compared 4-6 weeks after barrier placement, oligochaetes were the most abundant major taxon in reference site sediments. However, oligochaetes shared dominance much more equally with chironomids at both Eau Galle and Guntersville than at Lewisville. Oligochaete comprised 37.9 percent and 42.0 percent of the community at Eau Galle and Guntersville, respectively, but were heavily dominant at Lewisville (72.7 percent). Chironomids were more abundant at Eau Galle (25.4 percent) and Guntersville (25.0 percent) than at Lewisville (4.6 percent). In addition to oligochaetes and chironomids, trichopterans (17.5 percent) at Eau Galle and amphipods (13 percent) at Guntersville and gastropods (mostly *Physa* and *Biomphilaria*; 10.6 percent) at Lewisville were moderately abundant in reference site sediments.

Community composition in the area affected by the barrier at Eau Galle differed slightly from conditions in areas unaffected by the barrier (Figure 8). Reference site sediments were dominated by oligochaetes and chironomids. Beneath the barrier the benthic macroinvertebrate community was dominated by amphipods, although oligochaetes, chironomids, and trichopterans remained relatively abundant. At Guntersville, chironomids were

eliminated by benthic barriers, with affected sediments including only oligochaetes (67.0 percent) and nematodes (33.0 percent) (Figure 9).

As with density, effects of barriers on community composition at Lewisville were similar to those at Guntersville Lake and more pronounced than at Eau Galle. The study at Lewisville revealed changes in relative abundance of oligochaetes, chironomids, and nematodes (Figure 10). The pre-barrier community in the Lewisville ponds was heavily dominated by oligochaetes (82.6 percent), with the remainder of the community being comprised of chironomids (6.6 percent), ephemeropterans (5.7 percent), nematodes (3.3 percent), coleopterans (3.3 percent), and dipterans other than chironomids (0.6 percent). During the entire time that barriers were in place (11 June to 16 November), chironomids were never observed under barriers but comprised 12.3 percent of the community at reference sites. Oligochaetes, although still dominant, declined from the pre-barrier relative abundance of 82.6 percent to 68.0 percent and 64.9 percent at reference and barrier sites, respectively. Nematodes remained relatively unimportant at reference sites (3.7 percent) but increased in relative abundance under barriers (22.8 percent).

Recovery of Community Composition After Barrier Removal

As with density, recovery of the macroinvertebrate community at the Lewisville ponds was indicated by the relative abundance of major taxonomic groups (Figure 10). On 2 July 1991, subsequent to barrier removal the previous November, chironomids and oligochaetes shared dominance of the macroinvertebrate community at both reference and barrier sites. These two taxa combined comprised 89.5 percent of the community at reference sites and 96.0 percent of the community at barrier sites. Both prior to and during barrier placement, oligochaete relative abundance was consistently high and generally similar at reference sites and under barriers. Oligochaete abundance remained high at reference sites (63.4 percent) and barrier sites (48.0 percent) after barrier removal. Conversely, chironomids, which were eliminated under barriers while increasing in abundance at reference sites, recovered strongly once barriers were removed. Chironomids comprised 48.0 percent of the community at ex-barrier sites in comparison to 26.1 percent of the community at reference sites in July 1991.

4 Discussion

Results of the present study indicate that synthetic benthic barriers used for submersed aquatic macrophyte control cause large and rapid reduction in the density of macrobenthos. This biological effect was observed in a small Wisconsin reservoir, a large Tennessee River reservoir, and small ponds in north central Texas. Reduction of macrobenthos density ranged from approximately 70 percent in Wisconsin to greater than 90 percent in both the Alabama and Texas study locations.

Density reduction is rapid and sustained as long as barriers are in place. At the Lewisville ponds in Texas, massive reduction in benthic macroinvertebrate density occured within 1 week after barrier placement. Although all macroinvertebrates decline in absolute abundance under barriers, the relative abundance of chironomids tended to decline disproportionately to that of other groups, including nematodes and oligochaetes, at both Lewisville and Guntersville.

Recovery was strong in terms of both density and community composition once barriers were removed in the Lewisville ponds. Approximately 8 months after barrier removal, density had risen from just a few hundred individuals per square metre to well over 2,000 individuals per square metre. In addition, chironomids which had been eliminated from under barriers became abundant once barriers were removed.

Results at Eau Galle Reservoir were in general agreement with Engel's (1984) observations of effects of a synthetic barrier on macroinvertebrates in Cox Hollow Lake, also in Wisconsin. His data indicate that in late July, after 2.5 months of barrier treatment, density in a reference site was approximately 16,000 individuals per square metre while macrobenthos under barriers averaged 4,000 individuals per square metre. This 75-percent reduction corresponds closely to a 65-percent reduction indicated at Eau Galle 1 month after barrier placement, when 2,363 individuals per square metre were sampled from under barriers versus 6,792 individuals per square metre in reference site sediments. An 86-percent reduction was noted by the following summer when reference site density averaged 5,710 individuals per square metre versus 791 individuals per square metre under the barrier.

The rate of decline in macroinvertebrate density at the Lewisville ponds, in north central Texas, was much more rapid than the rate of decline observed by Engel (1984). He noted a progressive decline in density from May to June to July to August, whereas, at the Lewisville ponds, density fell within 1 week to a near-zero level that was sustained throughout the growing season. Differences between the two studies that may account for the slower decline in the Cox Hollow Lake study include lower water temperature and higher macrobenthos density as well as greater diversity in the Wisconsin Lake than the Texas ponds.

Natural temporal variation in benthos density was substantial at reference sites in the present study as well as that by Engel (1984). This variation is a consequence of the short lifespan of many organisms that dominate lake and pond sediments. Relatively short-lived, small, and rapidly growing macroinvertebrates present a dynamic community to be sampled, with reproduction, insect emergence, recruitment, and mortality all potentially causing demographic changes within the time frame of even just a few weeks. Thus, it is inappropriate to simply contrast initial density and community composition to subsequent density and composition. Quantitative evaluation of the effects of barrier placement must involve comparison of reference locations to treated sites.

Physical and chemical changes occur beneath barriers (Gunnison and Barko 1992; Eakin 1992) that are likely to be extremely deleterious to most macrobenthic communities that naturally occur in a plant bed. Especially problematic is reduced availability of dissolved oxygen just above the hydrosoil, presumably because diffusion of oxygen through the barriers cannot keep pace with the oxygen demands of decomposing plants and organically enriched sediments as well as animal respiration. Although many aquatic macroinvertebrates can withstand some degree of anoxia or hypoxia, sustained conditions of near-zero dissolved oxygen cause extensive mortality. Parallel studies of the physical effects of barriers at Eau Galle Reservoir, Lake Guntersville, and the Lewisville ponds all indicated extremely hypoxic conditions under barriers at all locations (Eakin 1992). Engel (1984) alluded to similar hypoxia under barriers in Cox Hollow Lake. Extremely hypoxic conditions during the first week of barrier placement at Lewisville are likely to have resulted from initial plant decomposition under the barriers. Such conditions would account for the rapid and massive decline observed in macroinvertebrate density.

In addition, ammonium nitrogen measured in interstitial water increased as a result of barrier placement in Lake Guntersville, although decreased ammonium nitrogen was reported at Eau Galle Reservoir (Eakin 1992). Free ammonia is generally toxic to aquatic life at concentrations of 2.5 mg/L (Reid 1961). Ammonium concentrations increase rapidly with depth in sediment cores and with organic content of the hydrosoil (Eakin 1992). Thus, increased ammonium concentrations are to be expected under most benthic barriers. High concentrations of ammonium in interstitial water of the upper hydrosoil layer, combined with hypoxic conditions, are likely to have a synergistic toxic effect (Downing and Merkins 1955). Furthermore,

Gunnison and Barko (1992) have observed evolution of toxic methane from decomposing plant material beneath barriers.

Not all biological effects of benthic barriers are necessarily negative. Loss of productive invertebrate habitat may be compensated to some extent by other potentially beneficial aspects of barrier placement. For example, sport fish may forage more effectively in open areas and channels among otherwise dense plants (Engel 1985). In addition, it has been the authors' personal observation that benthic barriers develop their own relative dense epibenthic fauna (Engel 1984), and, due to the structural simplicity of the upper side of a barrier in a weed-free zone, it is not unreasonable to expect that invertebrate-feeding fishes will successfully exploit this epibenthic food resource (Thorp 1988).

Submersed aquatic weeds are known to provide important and highly productive habitat to a variety of benthic (Beckett, Aartila, and Miller 1992a) and epiphytic macroinvertebrates (Beckett, Aartila, and Miller 1992b, 1992c; Cyr and Downing 1988; Schramm, Jirka, and Hoyer 1987). Clearly, benthic barrier use has a negative effect on these naturally occurring macroinvertebrate communities. Based on results presented herein and by Engel (1984), barrier use causes marked reduction in density and substantial change in composition of benthic macroinvertebrate communities immediately under barriers (Engel 1984; this study). However, both qualitative (community composition) and quantitative (density) recovery are evident once barriers are taken away. Furthermore, the small area affected by barriers relative to the total littoral zone of most lakes and reservoirs where barriers are used reduces the system-wide importance of localized loss of benthos.

References

Beckett, D. C., Aartila, T. P., and Miller, A. C. (1992a). "Contrasts in density of benthic invertebrates between macrophyte beds and open littoral patches in Eau Galle Lake, Wisconsin," *American Midland Naturalist* 127, 77-90.

________. (1992b). "Invertebrate abundance on *potamogeton nodosus*: Effects of plant surface area and condition," *Canadian Journal of Zoology* 70, 300-306.

________. (1992c). "Seasonal change in plant-dwelling chironomidae and naididae in a Wisconsin Lake," *Journal of Freshwater Ecology* 7, 45-57.

Born, S. M., Wirth, T. L., Brick, E. M., and Peterson, J. P. (1973). "Restoring the recreational potential of small impoundments; The Marion Millpond experience," Technical Bulletin 71, Wisconsin Department of Natural Resources, Madison, WI.

Cooke, G. D. (1986). "Sediment surface covers for macrophyte control." *Lake and reservoir restoration*. G. D. Cooke et al., eds., Butterworth, Stoneham, MA, 349-360.

Cooke, G. D., and Gorman, M. E. (1980). "Effectiveness of Du Pont Typar sheeting in controlling macrophyte regrowth after winter drawdown," *Water Resources Bulletin* 16, 353-355.

Cyr, H., and Downing, J. A. (1988). "Empirical relationships of phytomacrofaunal abundance to plant biomass and macrophyte bed characteristics," *Canadian Journal of Fisheries and Aquatic Sciences* 45, 976-984.

Downing, K. M., and Merkins, J. C. (1955). "The influence of dissolved oxygen concentration on the toxicity of unionized ammonia to rainbow trout (*Salmo gairdneri* Richardson)," *Annals of Applied Biology* 43, 243-246.

Eakin, H. L. (1992). "Effects of benthic barrier placements on aquatic habitat conditions." *Proceedings, 26th annual meeting, Aquatic Plant Control Research Program*, Miscellaneous Paper A-92-2, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

Engel, S. (1984). "Evaluating stationary blankets and removable screens for macrophyte control in lakes," *Journal of Aquatic Plant Management*, 22, 43-48.

Engel, S. (1985). "Aquatic community interactions of submerged macrophytes," Technical Bulletin No. 156, Wisconsin Department of Natural Resources, Madison, WI.

Gunnison, D., and Barko, J. W. (1992). "Factors influencing gas evolution beneath a benthic barrier." *Journal of Aquatic Plant Management* 30, 23-28.

Lewis, D. H., Wile, I., and Painter, D. S. (1983). "Evaluation of Terratrack and Aquascreen for control of aquatic macrophytes," *Journal of Aquatic Plant Management* 21, 103-104.

Mayer, J. R. (1978). "Aquatic weed management by benthic semi-barriers," *Journal of Aquatic Plant Management* 21, 31-33.

Nichols, S. A. (1974). "Mechanical and habitat manipulation for aquatic plant management. A review of techniques," Technical Bulletin No. 77, Wisconsin Department of Natural Resources, Madison, WI.

Reid, G. K. (1961). *Ecology of inland waters and estuaries*. Von Nostrand Reinhold, New York.

Schramm, H. L., Jr., Jirka, K. J., and Hoyer, M. V. (1987). "Epiphytic macroinvertebrates as a food resource for bluegills in Florida lakes," *Journal of Freshwater Ecology* 4, 151-161.

Simpson, E. H. (1949). "Mesurement of diversity," *Nature* 163, 688.

Thorp, J. H. (1988). "Patches and the responses of lake benthos to sunfish nest-building," *Oecologia* 76, 168-174.

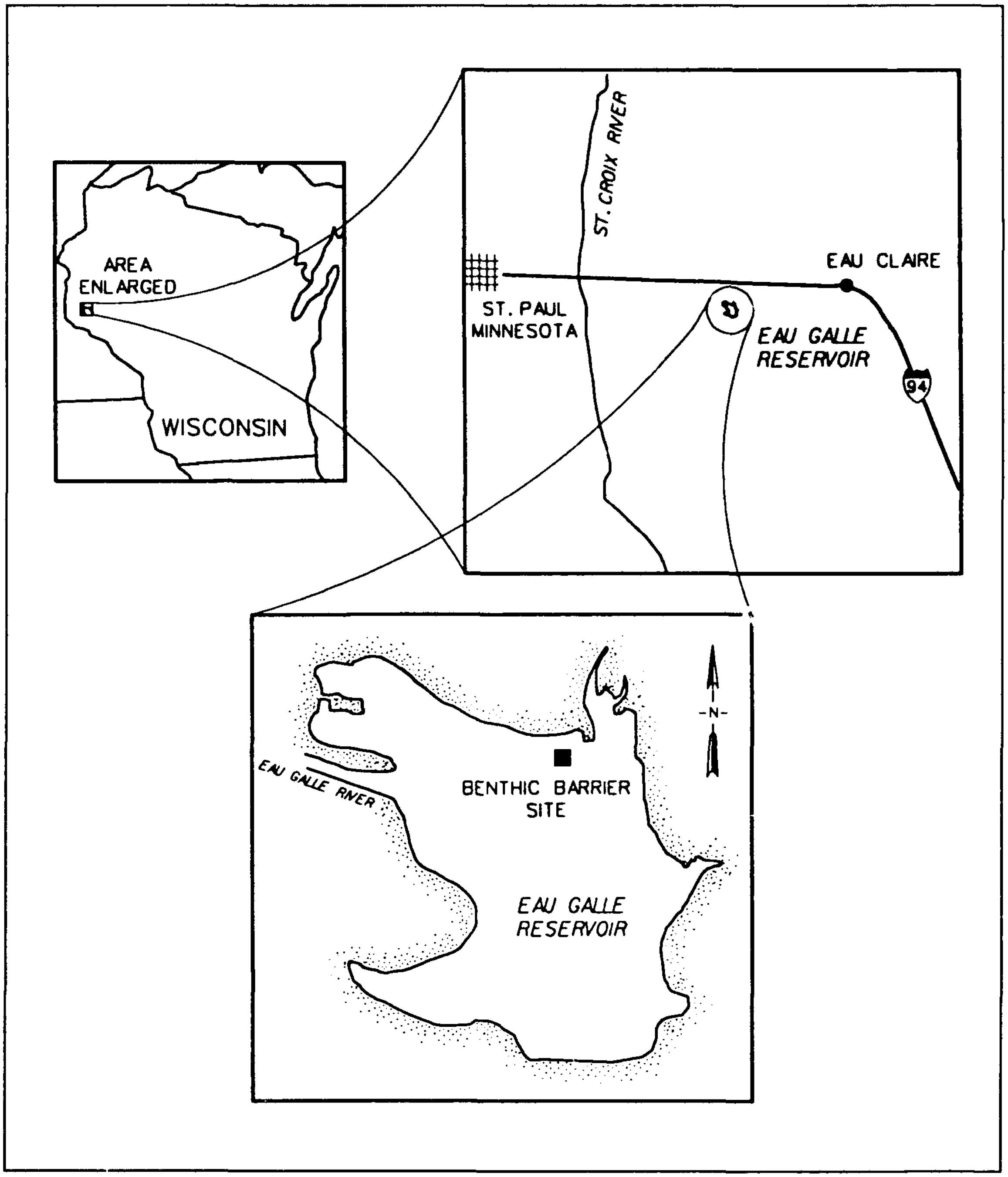


Figure 1. Location of Eau Galle Reservoir study sites in Wisconsin

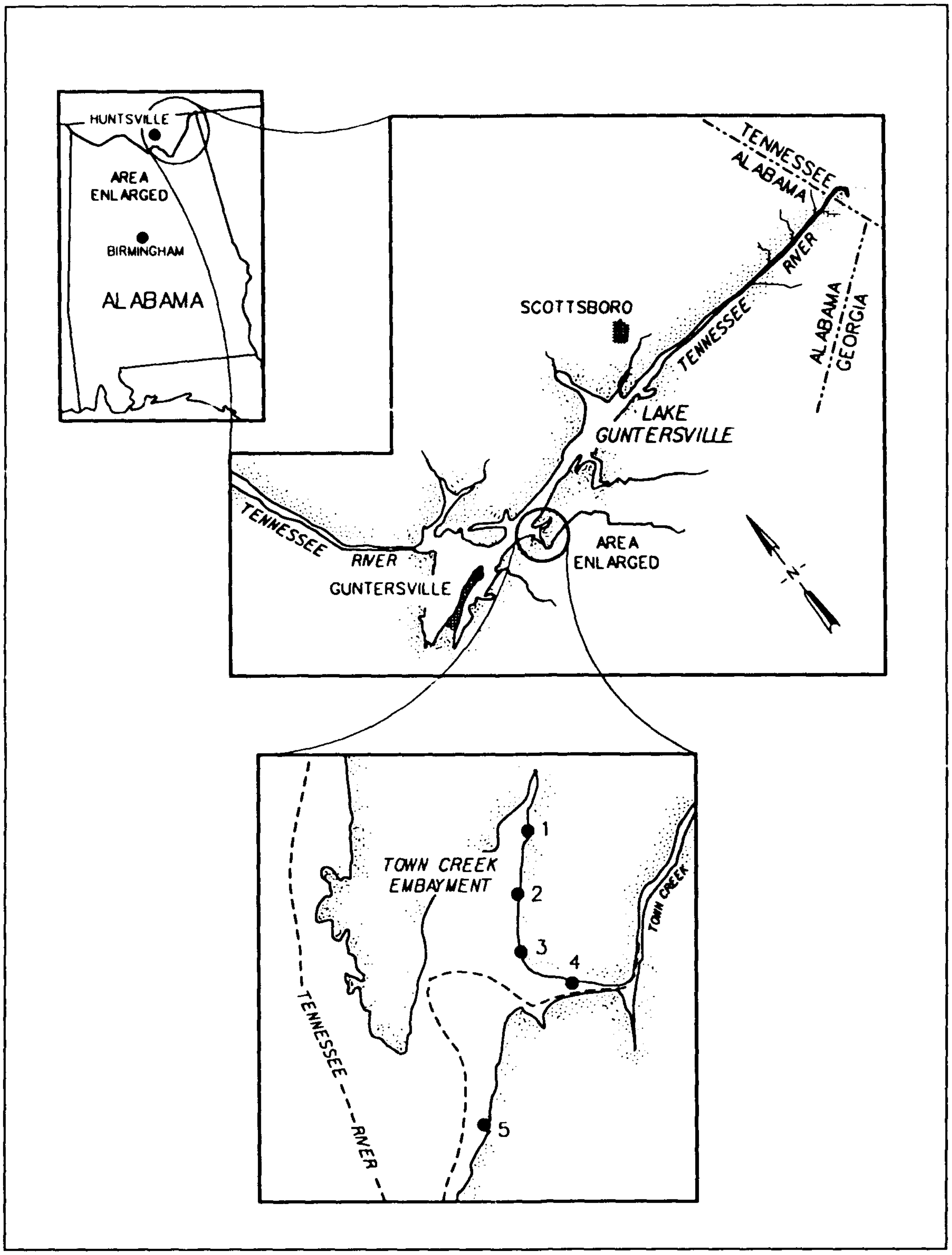


Figure 2. Location of Guntersville Lake study sites in Alabama

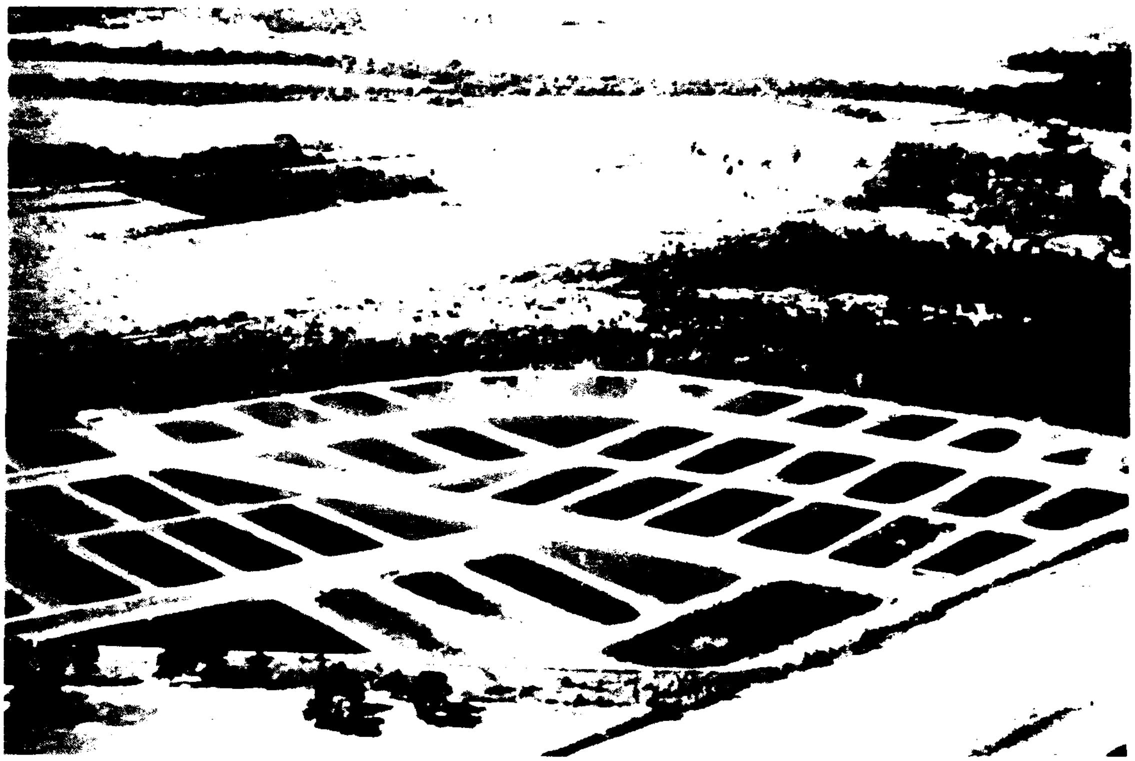


Figure 3. Photograph of ponds of Lewisville Aquatic Ecosystem Research Facility (taken from dam of Lewisville Reservoir), Lewisville, TX

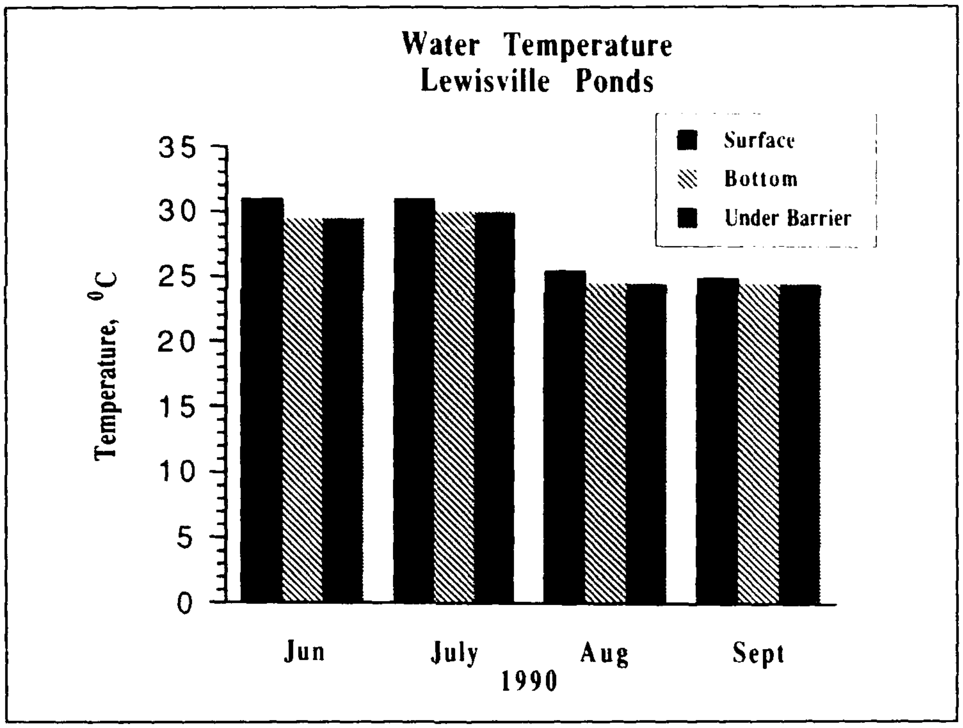


Figure 4. Surface, near-bottom, and under-barrier water temperatures at Lewisville ponds

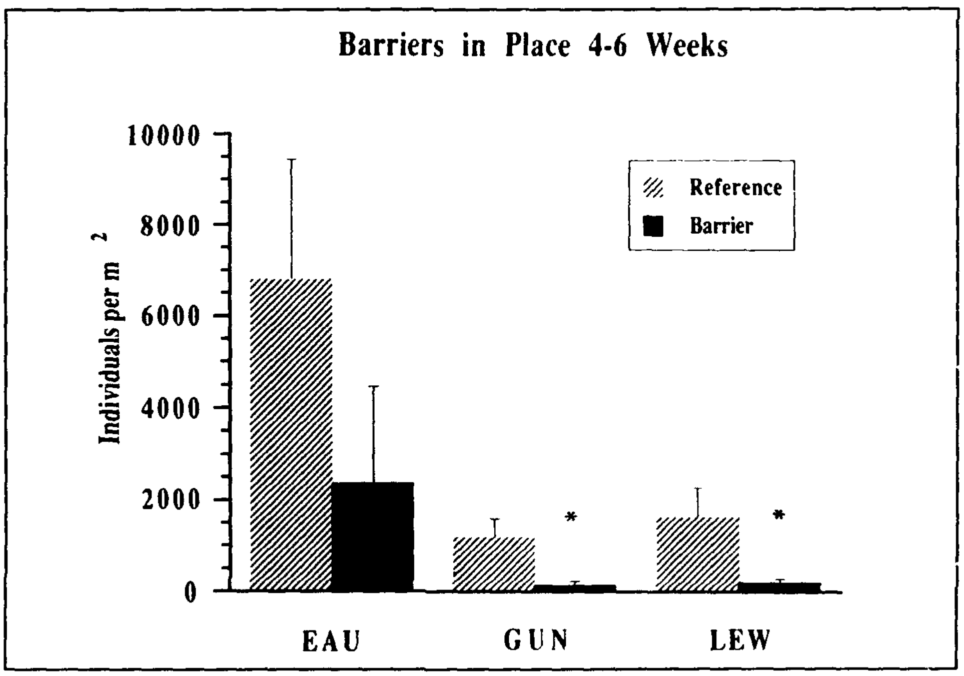


Figure 5. Comparison of macroinvertebrate density in sediments of reference sites and under barriers 4-6 weeks after placement at Eau Galle, Guntersville, and Lewisville. Asterisks indicate a significant difference (t-test; $p > 0.05$) between barrier and reference site

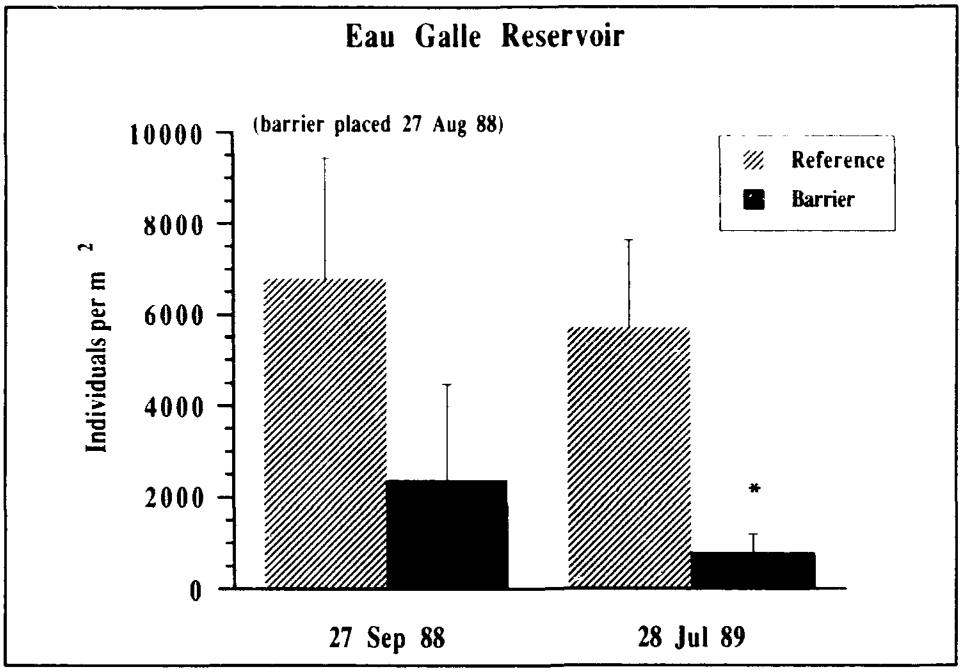


Figure 6. Initial post-placement and 1-year post-placement estimates of macroinvertebrate density in sediments at a reference site and under a barrier at Eau Galle. Asterisks indicate a significant difference (t-test; $p > 0.05$) between barrier and reference site

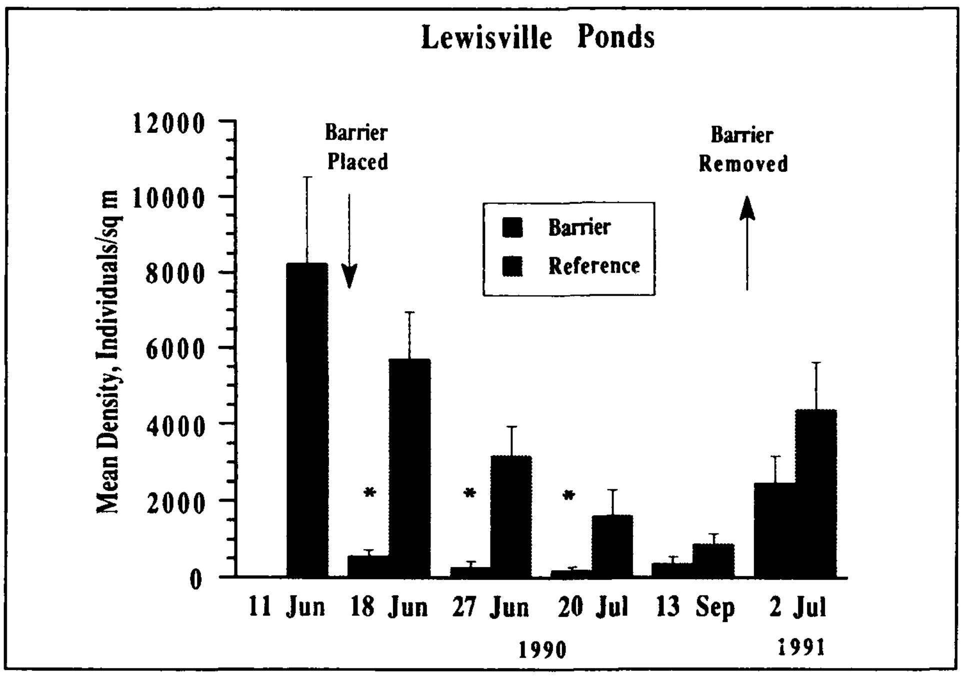


Figure 7. Estimates of macroinvertebrate density in sediments of reference and barrier sites in Lewisville ponds before barrier placement, during barrier treatment, and after barrier removal. Asterisks indicate a significant difference (t-test; $p > 0.05$) between barrier and reference site

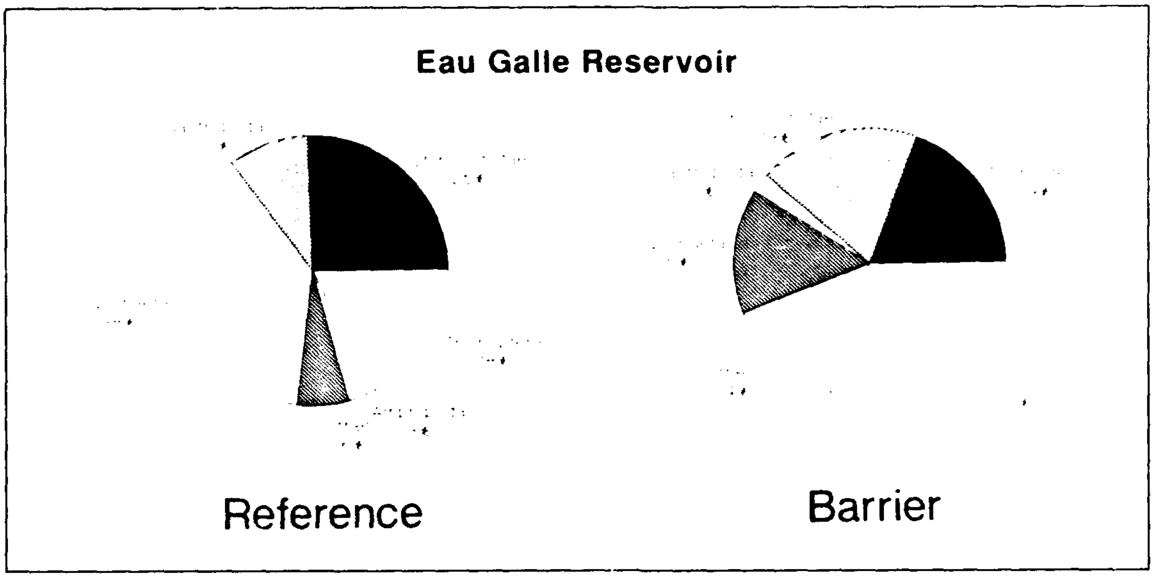


Figure 8. Macroinvertebrate community composition in sediments sampled from a reference site and under a barrier at Eau Galle Reservoir

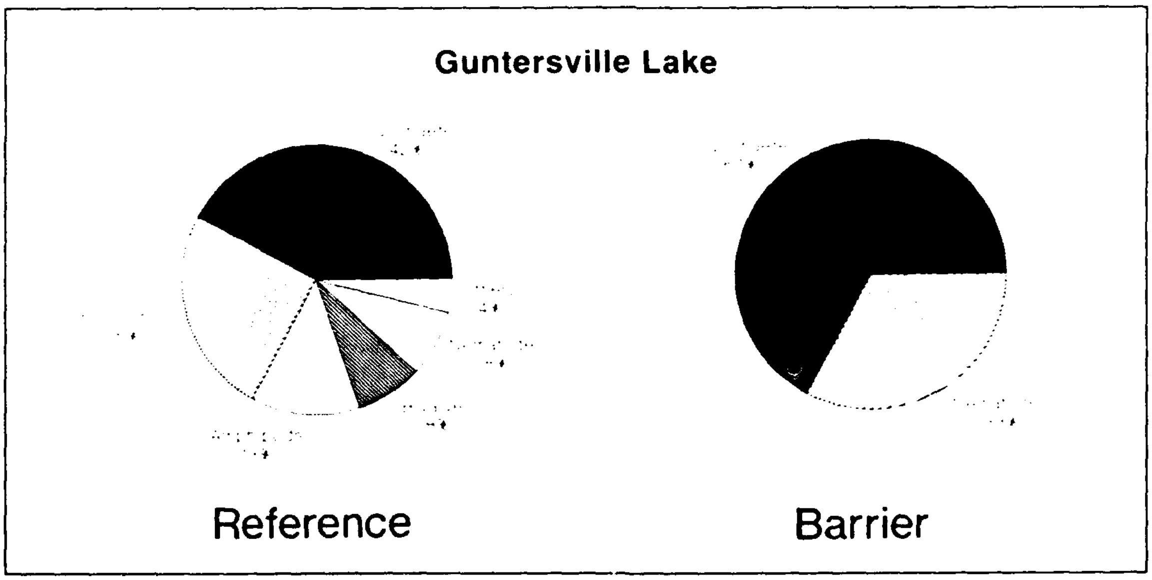


Figure 9. Macroinvertebrate community composition in sediments from reference sites and under barriers at Guntersville Lake

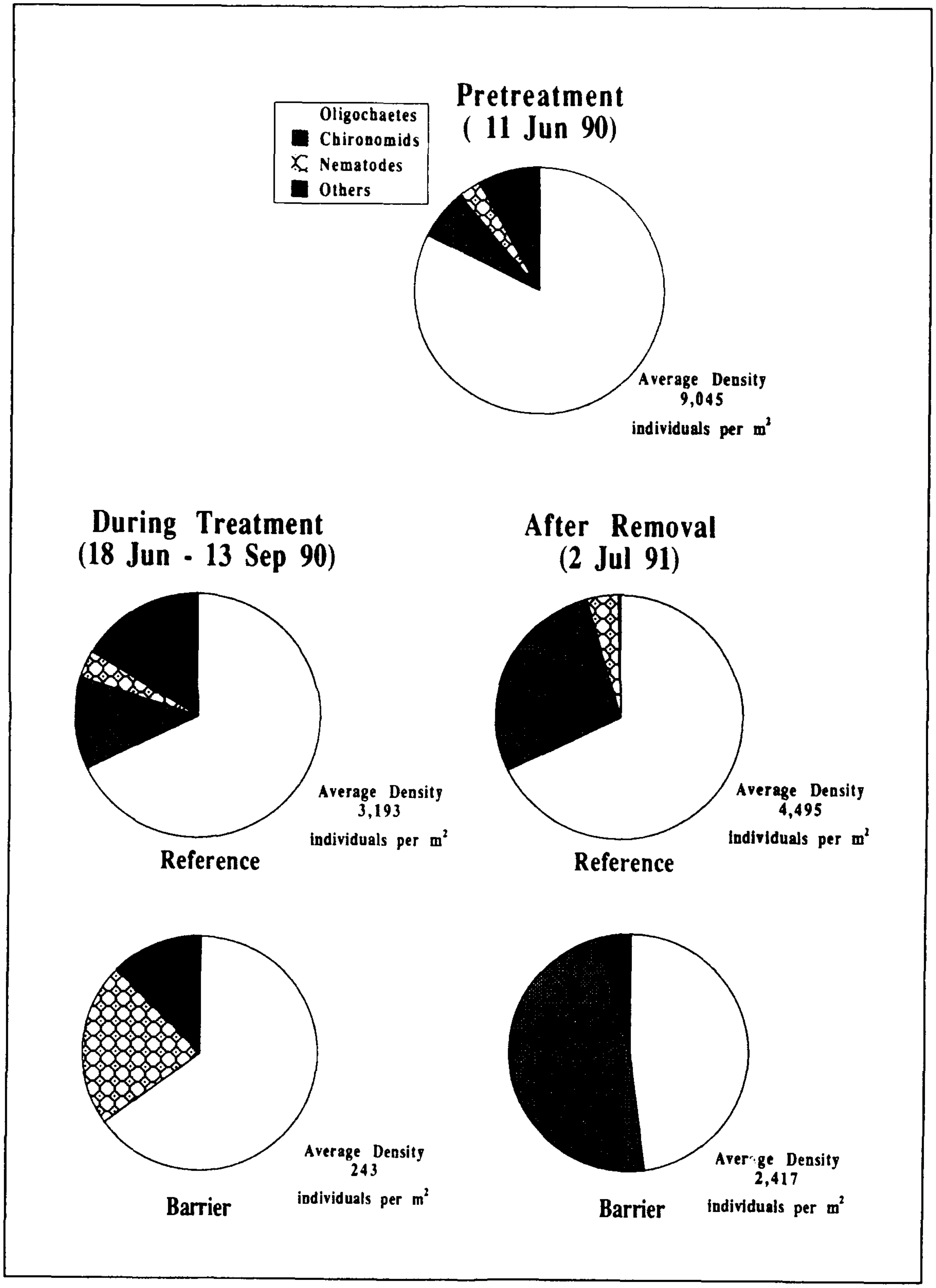


Figure 10. Macroinvertebrate community composition in sediments from reference sites and under barriers at the Lewisville ponds

Table 1
Summary of Density Estimates at Lewisville Ponds with Student's t-Test for Referene Versus Barrier Treatments

Summary of Density Data

Date	Treatment	Individuals per square metre		
		Mean	**SE**	**n**
11 Jun1990	Pre-barrier	8,240	2,283	20
18 Jun 1990	Reference	5,723	1,225	20
	Barrier	567	169	20
27 Jun 1990	Reference	3,182	778	20
	Barrier	271	177	20
20 Jul 1990	Reference	1,528	659	20
	Barrier	197	91	20
13 Sep 1990	Reference	888	269	20
	Barrier	370	186	20
2 Jul 1991	Reference	4,391	1,244	10
	Post-barrier	2,467	698	10

Summary of Student's t-Tests

Date	t	d.f	p
18 Jun 1990	4.17	38	<0.001
27 Jun 1990	3.65	38	<0.001
20 Jul 1990	2.15	38	<0.05
13 Sep 1990	1.58	38	>0.1 NS
2 Jul 1991	1.62	18	>0.1 NS

Table 2
Comparison of Community Composition of Macroinvertebrates[1]

Major Taxon	Relative Abundance, percent		
	Eau Galle	Guntersville	Lewisville
Oligochaetes	37.9	42.0	72.7
Chironomids	25.4	25.0	4.6
Trichopterans	17.5	0.0	0.0
Gastropods	9.6	0.0	10.6
Bivalves	0.0	8.0	0.0
Amphipods	3.4	13.0	0.0
Nematodes	2.6	8.0	3.3
Ephemeropterans	1.3	0.0	5.7
All others	2.3	4.0	3.1
	Simpson's Index of Dominance[2]		
	0.25	0.27	0.55

[1] Samples were taken from reference site sediments at Eau Galle Reservoir, Guntersville Lake, and Lewisville ponds 4-6 weeks after barrier placement.
[2] The sum of squares of each relative abundance value divided by 100 (Simpson 1949); the group "all other" was treated as a taxon in this computation of dominance.

REPORT DOCUMENTATION PAGE

Form Approved
OMB No 0704-0188

1. AGENCY USE ONLY *(Leave blank)*	2. REPORT DATE	3. REPORT TYPE AND DATES COVERED
	October 1993	Final report

4. TITLE AND SUBTITLE
Effects of Benthic Barriers on Macroinvertebrate Communities

5. FUNDING NUMBERS
WU 32579

6. AUTHOR(S)
Barry S. Payne, Andrew C. Miller, Thomas Ussery

7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)
U.S. Army Engineer Waterways Experiment Station, Environmental Laboratory, 3909 Halls Ferry Road, Vicksburg, MS 39180-6199;
University of Texas, Arlington, TX 76019

8. PERFORMING ORGANIZATION REPORT NUMBER
Technical Report A-93-5

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
U.S. Army Corps of Engineers
Washington, DC 20314-1000

10. SPONSORING/MONITORING AGENCY REPORT NUMBER

11. SUPPLEMENTARY NOTES
Available from National Technical Information Service, 5285 Port Royal Road, Springfield, VA 22161.

12a. DISTRIBUTION/AVAILABILITY STATEMENT
Approved for public release; distribution is unlimited.

12b. DISTRIBUTION CODE

13. ABSTRACT *(Maximum 200 words)*

Field experiments were conducted testing the effects of synthetic fabric barriers on benthic macroinvertebrates in Eau Galle Reservoir, Wisconsin, Lake Guntersville, Alabama, and ponds at the Lewisville Aquatic Ecosystem Research Facility of the Corps of Engineers in Lewisville, Texas. A large decline in macroinvertebrate density (70 - 90 percent) was noted within 4-6 weeks of barrier placement at all sites. Detailed monitoring at Lewisville revealed that the density decline was rapid, occurring within 1 week of barrier placement. Community composition changes were also noted, with chironomids being especially negatively affected at both Guntersville and Lewisville. Long-term studies at Eau Galle and Lewisville showed that effects were sustained as long as barriers remained in place. Studies of community recovery after barrier removal at Lewisville indicated near full recovery in terms of both density and relative abundance of major taxonomic groups.

14. SUBJECT TERMS
Aquatic plant control
Benthic barriers
Bottom screens
Environmental effects
Macroinvertebrates

15. NUMBER OF PAGES
27

16. PRICE CODE

17. SECURITY CLASSIFICATION OF REPORT	18. SECURITY CLASSIFICATION OF THIS PAGE	19. SECURITY CLASSIFICATION OF ABSTRACT	20. LIMITATION OF ABSTRACT
UNCLASSIFIED	UNCLASSIFIED		

NSN 7540-01-280-5500

Standard Form 298 (Rev 2-89)
Prescribed by ANSI Std Z39-18
298-102